(12) UK Patent Application (19) GB (11) 2 304 496 (13) A

(43) Date of A Publication 19.03.1997

(21) Application No 9516868.8

(22) Date of Filing 17.08.1995

(71) Applicant(s)
Motorola Limited

(Incorporated in the United Kingdom)

European Intellectual Property Operation, Jays Close, Viables Industrial Estate, BASINGSTOKE, Hampshire, RG22 4PD, United Kingdom

(72) Inventor(s)
Simon Everett Pike

(74) Agent and/or Address for Service
Christopher Stanislaw Hirsz
Motorola Limited, European Intellectual Property Operation, Midpoint, Alencon Link, BASINGSTOKE, Hampshire, RG21 7PL, United Kingdom

(51) INT CL^6
H01Q 21/00 , H04B 1/04 , H04Q 7/30

(52) UK CL (Edition O)
H4L LETXX L1H10
H1Q QHX

(56) Documents Cited
GB 2279504 A **GB 2243491 A** **GB 2182206 A**
GB 2006579 A **GB 1555591 A** **EP 0293099 A1**

(58) Field of Search
UK CL (Edition N) **H1Q QAX QFA QFF QHX , H4L LDSG LETXX**
INT CL^6 **H01Q 3/26 3/30 3/36 21/00 25/00 , H04B 1/02 1/04 7/06 , H04Q 7/30 7/36**
ONLINE : WPI

(54) Coupling radio transmitters to antenna elements

(57) A hybrid coupler 61 is arranged so that each of a plurality of transmitters 55,57 has its output 56 or 58 coupled to each of a plurality of antenna radiating elements 53, 54. The antenna elements 53,54 may be parts of the same antenna 52 or may be respective antennas (106,108,Fig7) covering separate areas. A desired radiation pattern is achieved by means of transmission lines and/or phase shifters 63,64 between the coupler 61 and the elements 53,54. The phase shifters may be adjusted by remote control to alter the radiation pattern during operation. A combination of four hybrid couplers (70-73,Fig.6) and four phase shifters (81-84) enables each of four transmitters to be coupled to each of four antenna elements (91-94). The number of radiating elements may be less than, equal to, or greater than the number of transmitters, and may be a power of two. The coupling arrangement may be used at a cellular radio base station. At least one of the radiating elements may also be used for diversity reception.

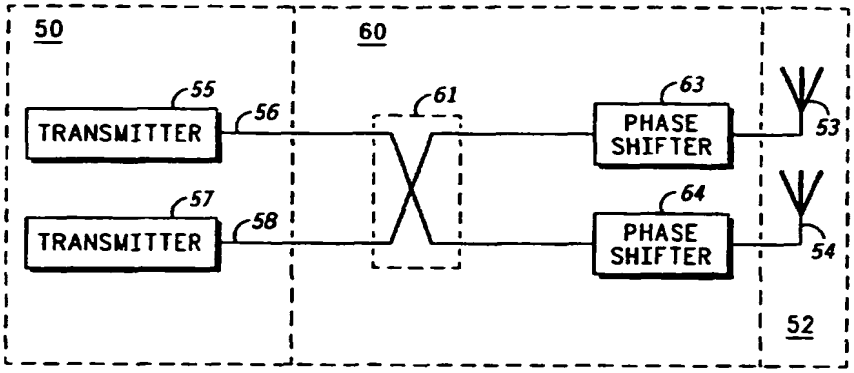
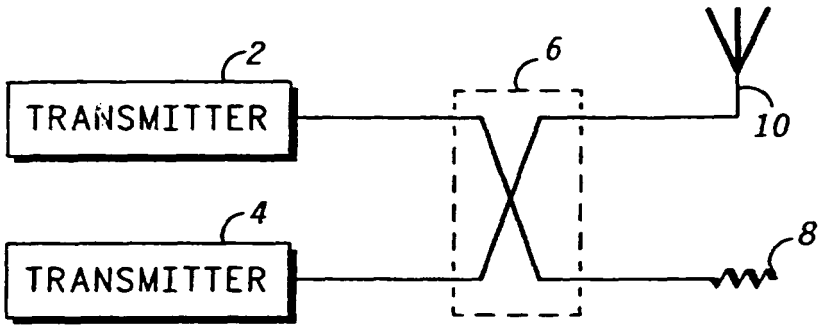


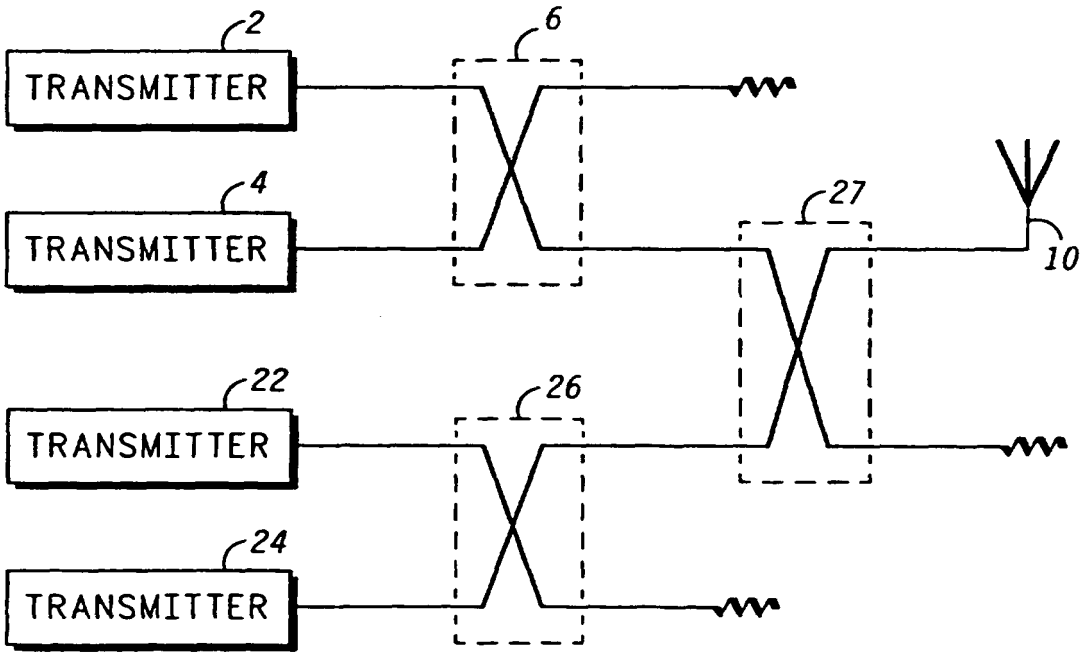
FIG. 5

GB 2 304 496 A



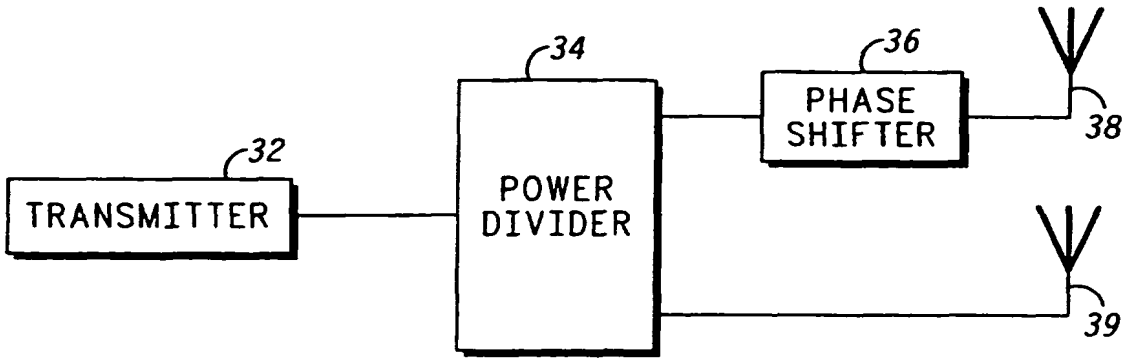
-PRIOR ART-

FIG. 1



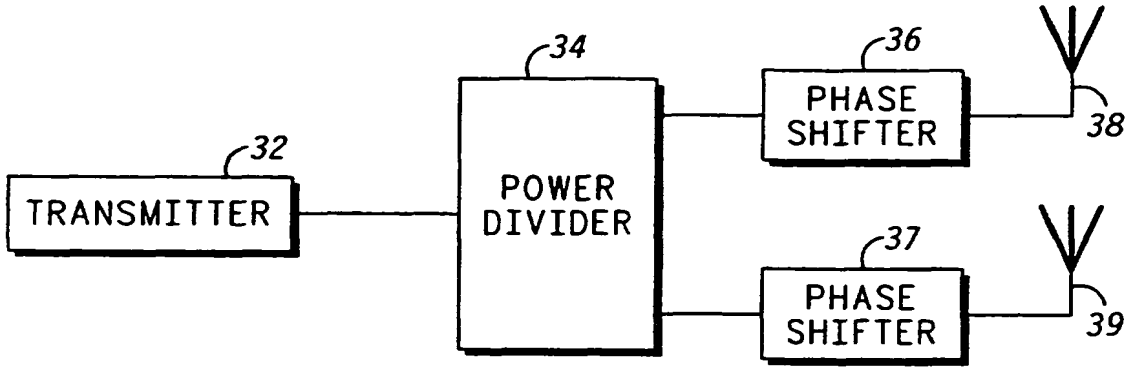
-PRIOR ART-

FIG. 2



-PRIOR ART-

FIG. 3



-PRIOR ART-

FIG. 4

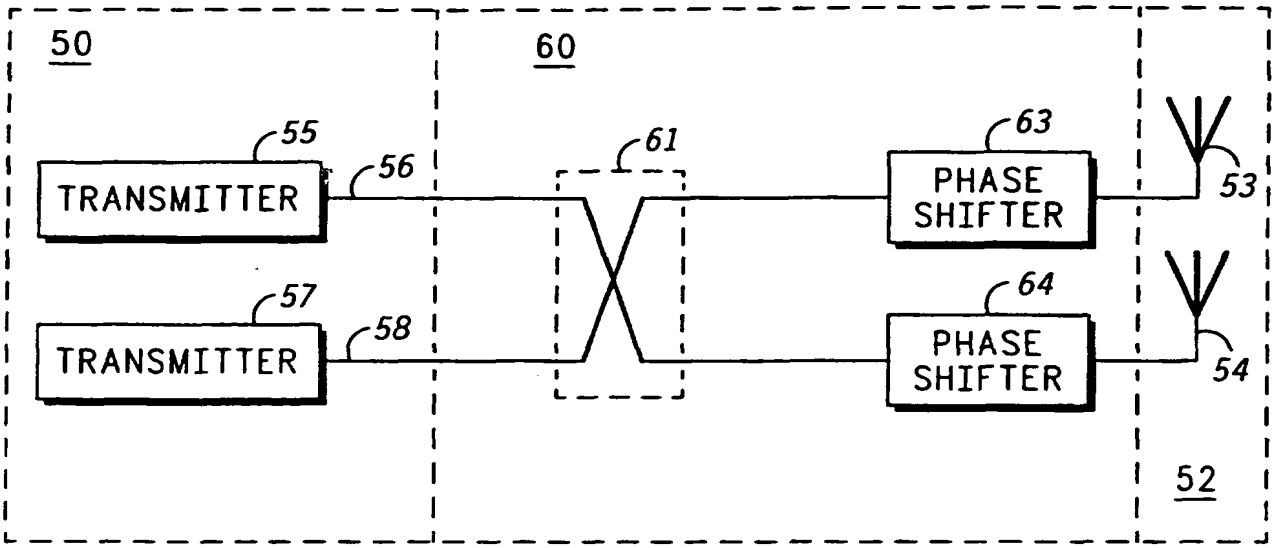


FIG. 5

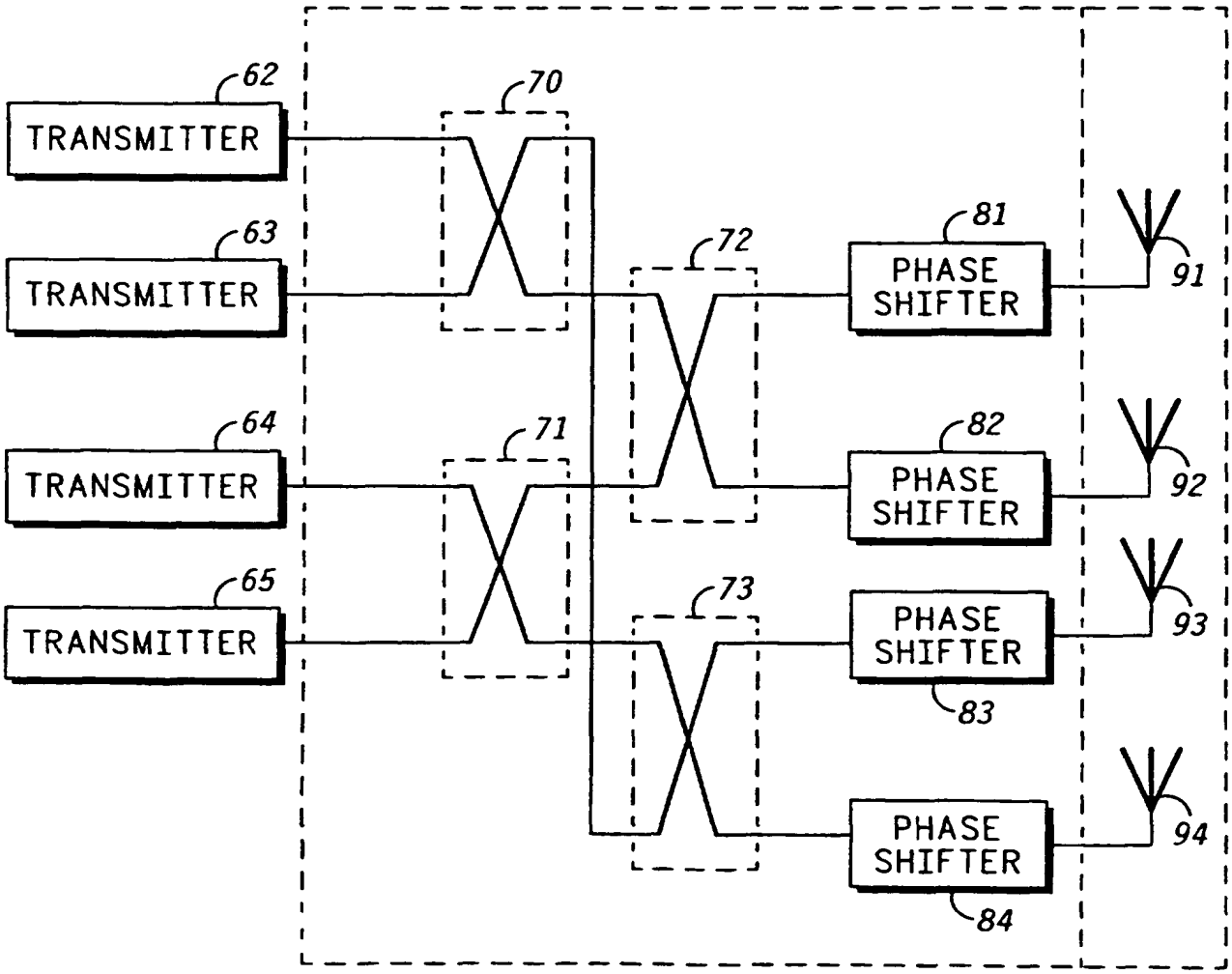


FIG. 6

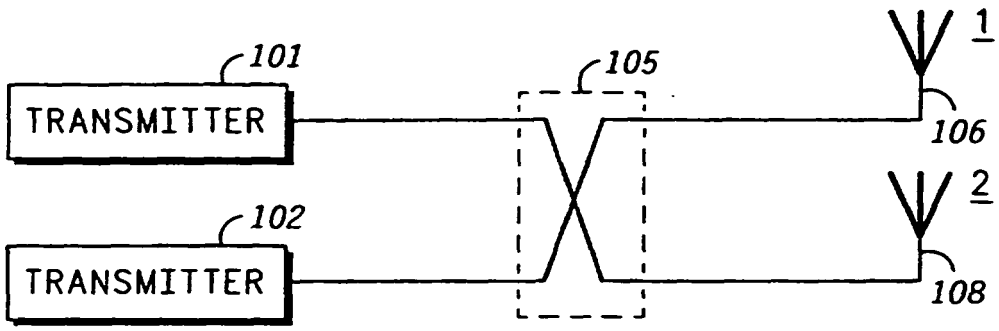


FIG. 7

APPARATUS FOR TRANSMITTING RADIO SIGNALS

Field of the Invention

This invention relates in general to an apparatus for transmitting radio signals at an antenna, and more particularly to an apparatus for combining transmitters to feed a common antenna.

Background to the Invention

Present communications systems, such as cellular radio systems divide an area over which communications service is to be offered into a number of smaller areas, called cells, each of which is served from a single base site. Often, the area to be served from a single base station site is divided into smaller areas, called sectors. The system determines which base station site, and which sector, is to be used for communication with a particular mobile station by making measurements on the signal received from the mobile (including its signal strength) at a number of fixed locations.

Each area to be served has a separate antenna at the base station site for transmitting to the mobile station. A signal is also received from the mobile station at the base station site using either a single antenna or more than one antenna (the latter being called diversity reception). Depending on circumstances, some or all of the antennas at the base station site may be used for both transmission and reception.

The properties of the antennas used at the base station site are chosen to optimise coverage of the desired area, and to minimise interfering signals transmitted to, and received from, other areas.

The number of radio channels needed to serve each area will depend on the number of mobile stations contained within it. if more than one radio channel is required, the outputs from each transmitter must be combined before being fed to the transmitter antenna.

The combining of the outputs of transmitters at cellular base sites is commonly achieved using one of two techniques:

1 A resonant combiner. This uses one filter per transmitter which is connected to a common 'manifold' which feeds the antenna. This technique is expensive and requires that the frequencies of the transmitters are separated by more that the pass band widths of the
5 filters.

2 Hybrid combiners. These are less expensive, and do not impose any constraints on the frequency separation of the transmitters. A hybrid combiner comprises a number of hybrid couplers and terminating
10 loads. A hybrid coupler is a reciprocal four port device in which the power applied to one port is divided equally between two of the remaining ports according to a defined relationship. For use in a hybrid combiner they are connected such that half of the power from each port connected to a transmitter leaves the output port; the other
15 half of the power is dissipated in a terminating load connected to the fourth port. Hybrid combiners therefore have a theoretical minimum attenuation of 3 dB. If the outputs from more than two transmitters must be combined, then hybrid combiners can be cascaded; in this case there is at lease 3dB loss in each stage.

20

If the loss of the combining is reduced, then a transmitter with lower output power can be used while still achieving the same performance from a radio communication system. This is a worthwhile improvement because transmitters with a high output power are
25 expensive to implement.

The technique of phased array antennas is well know to those skilled in the art. The antenna consists of a number of radiating elements. Each element is connected to a common port by a circuit which divides the power
30 from the transmitter to individual elements in the antenna in pre-determined proportions, and with pre-determined relative phases of the voltage (as measured at the input the radiating elements). If the power division ratio or the relative phase to the individual elements is changed, the characteristics of the aerial will be changed (in particular, the polar
35 distribution of radiated power from the antenna, also known as the radiation

pattern). By this means the radiation pattern of the antenna may be steered.

FIG. 1 illustrates how the outputs from a number of radio transmitters 2, 4 may be combined to feed a common antenna 10 using a hybrid coupler 6 and a terminating load 8.

FIG. 2 illustrates an extension of the technique of FIG. 1 where the outputs of four transmitters 2, 4, 22, 24 are combined using hybrid couplers 6, 26, 27 to feed a common antenna 10.

FIGs. 3 and 4 illustrate two alternative techniques to apply a relative phase shift between the radiating elements for an antenna. In FIG. 3, a phase shifting device 36 has been inserted in the transmission line between the power divider 34 and one of the radiating elements 38. Thus, an output of one transmitter 32 may be transmitted by an antenna array having two radiating elements 38, 39. In some circumstances it is preferable to insert a phase shifting device in the transmission lines between the power divider and both of the radiating elements, as shown in FIG. 4. Thus, FIG. 4 shows the output of one transmitter 32 transmitted by an antenna arrangement having two radiating elements 38, 39 each coupled to an output of a phase shifting device 36, 37. Such techniques may also be applied to antennas containing a larger number of radiating elements.

However, an improved method of combining the signals from the transmitters to feed a common antenna is required. Particularly, a method in which less of the transmitter power is lost in the combining circuitry and which allows the characteristics of the transmitting antenna to be varied so as to optimise operation for particular mobile stations.

Summary of the Invention

According to the present invention, an apparatus is provided for the transmission of radio signals including an antenna having a plurality of radiating elements, a plurality of transmitters each having a respective output; and means for combining each respective output from the transmitters to the radiating element of the antenna in predetermined portions.

Brief Description of the Drawing

FIG. 1 shows a technique for combining two transmitters into one antenna using a hybrid coupler.

FIG. 2 shows a technique to combine four transmitters into one antenna using hybrid couplers.

FIG. 3 shows a phased array antenna for an array of two elements.

FIG. 4 shows an alternative phased array antenna for an array of two elements.

FIG. 5 shows an antenna arrangement according to the present invention.

FIG. 6 shows an alternative antenna arrangement according to the present invention.

FIG. 7 shows an alternative antenna arrangement according to the present invention as applied to two antennas intended to cover separate coverage areas.

Detailed Description of the Preferred Embodiment

Referring to FIG. 5, there is shown an apparatus 50 for the transmission of radio signals including an antenna 52 having a plurality of radiating elements 53, 54, a plurality of transmitters 55, 57 each having a respective output 56, 58, and means for combining each respective output from the transmitters to the radiating element of the antenna in predetermined portions 60. The means for combining includes a hybrid coupler 61 and two phase shifters 63, 64.

An input of each radiating element 53, 54 of the antenna 52 may be connected to a control means for controlling a relative phase of the voltage at the input to the radiating element so that a predetermined polar distribution of power is radiated from the antenna. The control means for controlling the relative phase of the voltage may include a length of a transmission line. The control means for controlling the relative phase of the voltage may alternatively include a phase shifting means 63, 64.

The characteristics of the phase shifting means may be changed during operation of the apparatus so as to change the polar distribution of radiated power from the radiating elements of the antenna.

A further embodiment of the present invention includes that the number of radiating elements of the antenna equal to the number of transmitters.

FIG. 6 shows the present invention as it applies to four transmitters and four radiating elements of an antenna. Thus, four transmitting elements 62-65 are coupled to four hybrid couplers 70-73 and four phase shifters 81-84 for feeding four radiating elements 91-94.

The present invention is applicable in a cellular radio system where it is often required to combine the output of several transmitters to feed a single antenna. Each of these transmitters is connected to a combining circuit. This circuit divides the power from each transmitter equally between a number of output ports.

The antenna comprises a number of radiating elements, each of which has a separated connection via a transmission line to the combining circuit. These radiating elements are normally similar and arranged in a regular pattern. The relative phase of the RF voltage at the input to each radiating element is controlled to a pre-determined relationship, in order to achieve the required radiation pattern. This can be achieved in three ways:

1 The lengths of the transmission lines between the combining circuit and each of the radiating elements is chosen to give the pre-determined relationship.

2 A phase shifting device can be inserted into the transmission line between the combining circuit and each radiating element.

3 A combination of the two above.

In the second and third options above, it is possible to use phase shifting devices which can be adjusted by remote control. In this case it is possible to alter the radiation pattern of the antenna during operation.

In a preferred embodiment, the optimum number of radiating elements in the antenna is a power of two, and is equal to, or greater than, the number of transmitters. In this case, in theory, no power need be dissipated in the combining circuit. FIGs. 5 and 6 show examples for two and four transmitters respectively. However, the same technique can be applied to other numbers of radiating elements, and to a larger number of transmitters than radiating elements.

The radiating elements of the antenna may also be used as separate antennas for diversity reception. Thus, at least one of the radiating elements may also be used as a receiving antenna which is connected to an input of a diversity receiver.

It is possible to use a similar technique to combine the outputs from a number of transmitters to feed a number of antennas covering separate areas. FIG. 7 shows an example of two transmitters 101,102 feeding two separate antennas 106, 108 by using a hybrid coupler 105. If the coverage areas of the transmitters do not overlap, it is not necessary to control the relative phase of the voltage at the input to each antenna.

Thus, an apparatus for the transmission of radio signals may be provided including a plurality of antennas 106, 108, a plurality of transmitters 101, 102, each having a respective output, and means for combining each respective output from the transmitters to a respective input of each of the antennas 105.

The present invention overcomes a problem inherent in combining the outputs from more than one transmitter into a single antenna. The present invention uses hybrid combiners to allow more than one transmitter to share a single transmit antenna. Steerable antennas, including an array of radiating elements in which the proportion and phase of the power supplied to the radiating elements is defined so as to determine its radiation pattern are also used. By adjusting the proportion and/or phase, the radiation pattern may be changed. The antenna includes at least one power divider and phase shifter.

The present invention is an electrical network, also referred to as combining circuit, that provides an improved antenna arrangement. By combining the function of a hybrid combiner and a power splitter into one, the proportion of the transmitter power which is dissipated can be reduced. If the number of radiating elements in the antenna equals or exceeds the number of transmitters, then in theory none of the transmitter power need be dissipated in the combining circuit. The present invention also allows the radiation pattern to be changed to optimise transmission to a mobile station or stations. Depending on the application, either or both of these benefits may improve the performance of a mobile radio communications system.

It is also possible for outputs from the combining circuit to be connected to more than one antenna, each of which covers a distinct coverage area. An example of such an application is for serving roads, where two antennas would point in opposite directions along the road.

Claims

1. An apparatus for the transmission of radio signals comprising:
an antenna having a plurality of radiating elements;
a plurality of transmitters each having a respective output; and
means for combining each respective output from the transmitters to the radiating element of the antenna in predetermined portions.

2. The apparatus of claim 1 wherein the input of each radiating element of the antenna is connected to a control means for controlling a relative phase of the voltage at the input to the radiating element so that a predetermined polar distribution of power is radiated from the antenna.

3. The apparatus of claim 2 wherein the control means for controlling the relative phase of the voltage includes a length of a transmission line.

4. The apparatus of claim 2 wherein the control means for controlling the relative phase of the voltage includes a phase shifting means.

5. The apparatus of claim 4 wherein characteristics of the phase shifting means may be changed during operation of the apparatus so as to change the polar distribution of radiated power from the radiating elements of the antenna.

6. The apparatus of any of the preceding claims wherein the number of radiating elements of the antenna is equal to the number of transmitters.

7. The apparatus of any of the preceding claims wherein at least one of the radiating elements is also used as a receiving antenna which is connected to an input of a diversity receiver.

8. An apparatus for the transmission of radio signals comprising:
a plurality of antennas;
a plurality of transmitters each having a respective output; and
means for combining each respective output from the transmitters to a respective input of each of the antennas.

9. An apparatus for transmitting radio signals substantially as herein described with reference to FIGS. 5-7 of the drawing.

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9516868.8
Relevant Technical Fields (i) UK Cl (Ed.N) H1Q QAX, QFA, QFF, QHX; H4L LDSG, LECTXX (ii) Int Cl (Ed.6) H01Q 3/26, 3/30, 3/36, 21/00, 25/00; H04B 1/02, 1/04, 7/06; H04Q 7/30, 7/36	Search Examiner MR M J BILLING Date of completion of Search 27 OCTOBER 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1 to 9

Categories of documents

X:	Document indicating lack of novelty or of inventive step.	P:	Document published on or after the declared priority date but before the filing date of the present application.
Y:	Document indicating lack of inventive step if combined with one or more other documents of the same category.	E:	Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A:	Document indicating technological background and/or state of the art.	&:	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X;Y	GB 2279504 A	(MERCURY) Figures 2, 3	X: 1, 6, 7, 8; Y: 2-5 at least
Y	GB 2243491 A	(HALL) Figures 4, 5	2-5 at least
X	GB 2182206 A	(BBC) Figures 3, 4, 7; page 2 lines 3-36	1, 6, 8 at least
X;Y	GB 2006579 A	(NIPPON TELEGRAPH) Figures 4, 6, 8	X: 1, 6, 7, 8; Y: 2-5 at least
X;Y	GB 1555591	(FELTEN) Figure 1	X: 1, 6, 8; Y: 2-5 at least
Y	EP 0293099 A1	(HAZELTINE) Figure 1	2, 4, 5 at least

Databases:The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).